Linking Biodiversity and Wetland Geometry - an Example from Highway Stormwater Management Ponds in Southern Sweden

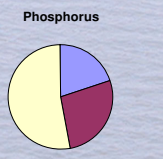
- **Dr. Lena Vought**
- **Dr. Jean Lacoursière**

Kristianstad University

- **Dr. Peder Hjorth**
- **Dr. Janusz Niemczynowicz**

Lund University

Sources of Nutrients
To the Baltic Sea



- Diffuse sources, especially agriculture biggest polluter

Origin of N and P entering surface waters in Southwest Scania (Sweden)

	N (%)	P (%)
Farming	88.0	52.0
Municipal sewage	5.4	5.2
Private sewage	0.2	23.1
Other sources	6.4	19.7

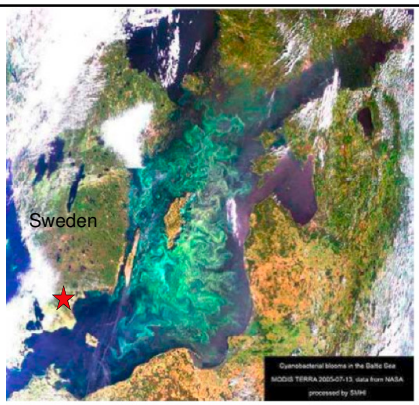
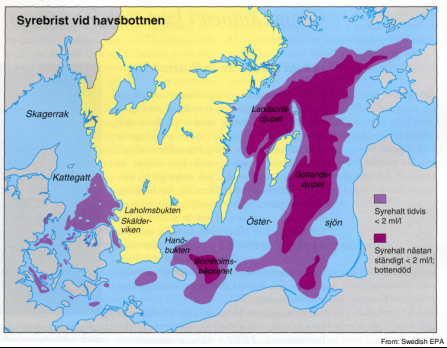


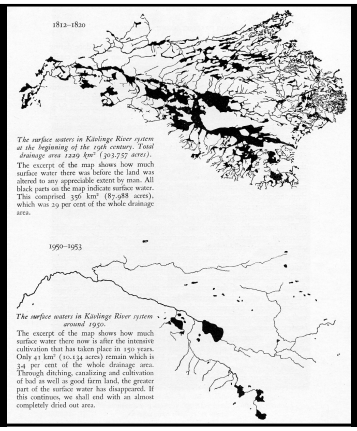
Figure 1.2. Cyanobacterial bloom in the Baltic Sea, July 13, 2005. From: Swedish EPA

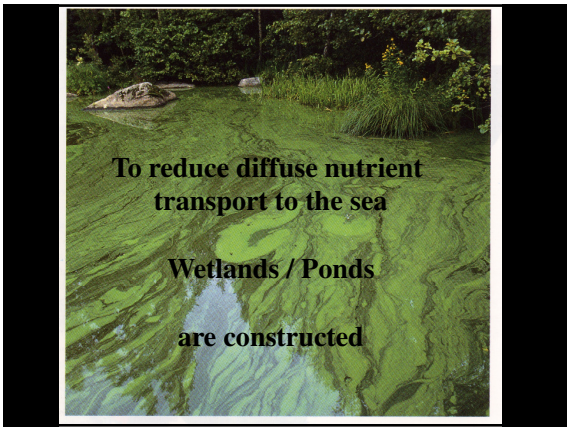
Areas without Oxygen in The Baltic Sea

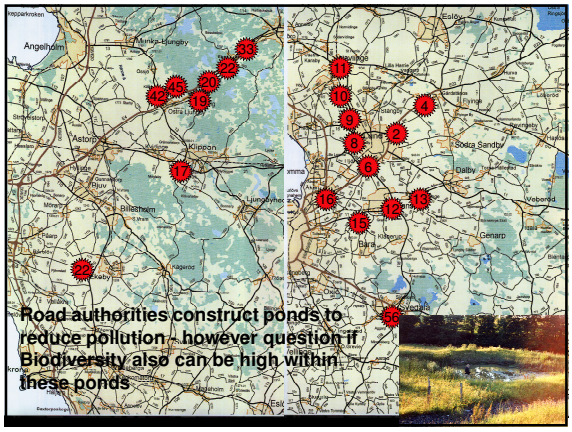


Syrehalter under 2 ml per liter vatten är livshotande för alla högre organismer i havet. Bottnar där syrehalten ständigt understiger den nivån är praktiskt taget döda. Kartan visar de syrefattiga bottnarnas utbredning kring 1990. — Data från Miljön, Sveriges Nationalatlas, samt SMHI.

From: Swedish EPA







Selection of four types of ponds

	"Good Pond"	"Bad Pond"
"Positiv environment"	6, 12, 56	8, 10, 11, 15, 16, 18
"Negative environment"	17, 19, 20, 24, 33	2, 4, 9, 13, 42, 45

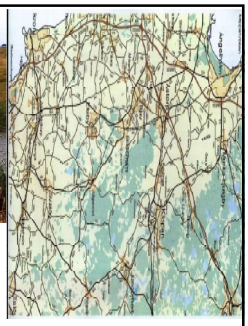
Four Types of Ponds

Table 2: General description of road ponds used in a biodiversity study.

Pond No	Dominant vegetation	Age	Max depth	Length /width (m)	Source, water
2	*Potamogeton natans*	1993	2.5	50x100	road/agri.
4	*Ceratophyllum demersum*	1993	1.5	40x120	agri./road
6	*Potamogeton crispus*	1996 ?	0.7	30x80	road
8	*Chara vulgaris, P. natans*	1996 ?	1	25x35	road
9	*P. natans*	1996 ?	1	20x30	road
10	*Veronica anagallis-aquatica*	1996 ?	0.5	15x30	road
11	*C. vulgaris*	1996 ?	2	25x50	road
12	*C. vulgaris, P. natans*	1996 ?	0.5	30x40	road
13	*P. natans*	1996 ?	0.8	30x40	road
15 in	*C. demersum*	1996 ?	0.5	20x30	road
15 out	*C. demersum, P. natans*	1996 ?	1.4	40x90	road
16	*P. natans, P. pectinatus*	1995 ?	0.7	30x35	agri./road
17	*P. natans*	old	1	13x13	road
18	-	1991	2.7	40x100	agri./road
19	-	1997	1.9	30x50	forest/road
20	-	1997	1.3	8x40	road
24	-	1997	1.6	12x16	forest/road
33	-	1996	1.6	7x20	road
42	Filamentous algae, *P. natans*	1997	0.6	20x70	road/agri.
45	Filamentous algae	1997	0.7	20x80	agri./road
56	*Typha latifolia*, Filam. algae	1995	0.7	15x60	road

Mapping
Water chemistry
Sediment chemistry
Benthic animals
Plants

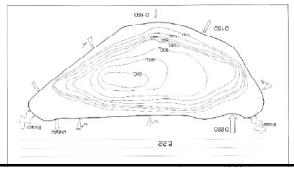
Area, Perimeter, Depth
Slope, Inflow, Outflow
N, P, pH, Color, Cond.
Metals, % Organic
No./species benthic animals,
Diversity, Eveness
No./species plants, % cover



Pond No 2

Pond No 4

Pond No 6

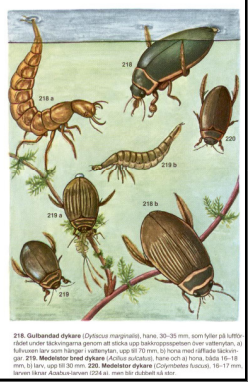


Legal limits for certain heavy metals (mg/g Dry Mass) in sewage sludge in Sweden. Limits are compared to concentrations in sediment in road ponds

Heavy metal	Limits mg/g DM	Ponds exciding limits
Pb	0,100	NO
Cd	0,002	NO
Co	0,008-0,020*	33
Cu	0,600	NO
Cr	0,100	NO
Hg	0,0025	NO
Mn	0,200-0,500*	17, 19, 24,33
Ni	0,050	NO
Zn	0,800	NO

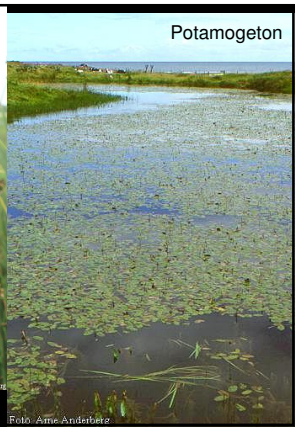
* only norm values

Kick Net

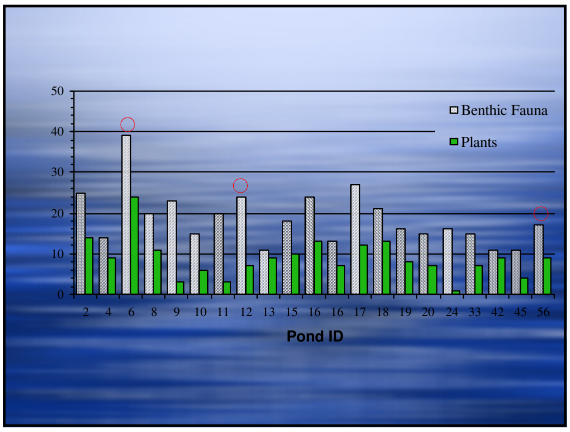


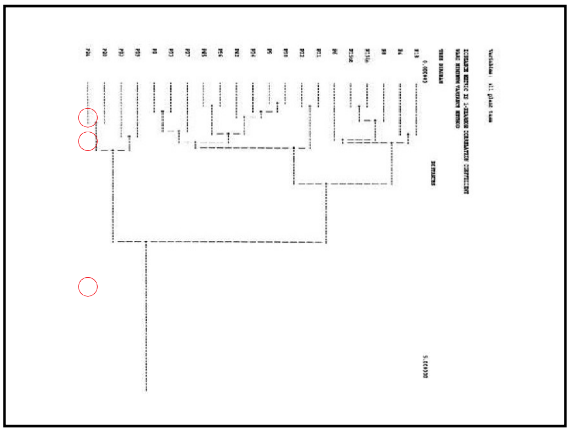
Benthic Animals

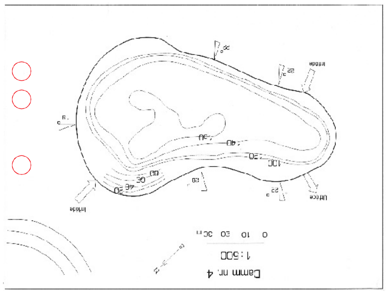
Cattail



Potamogeton







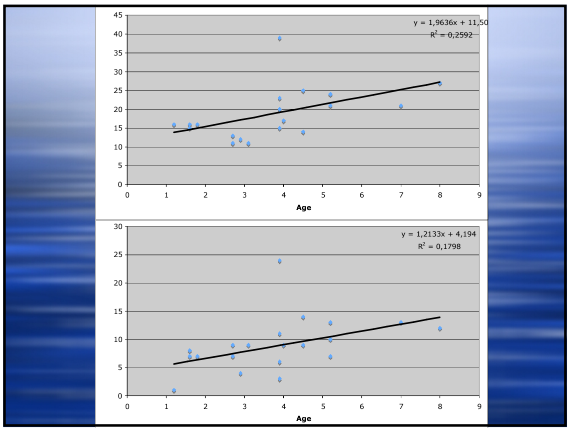
Tabel1 2. forts

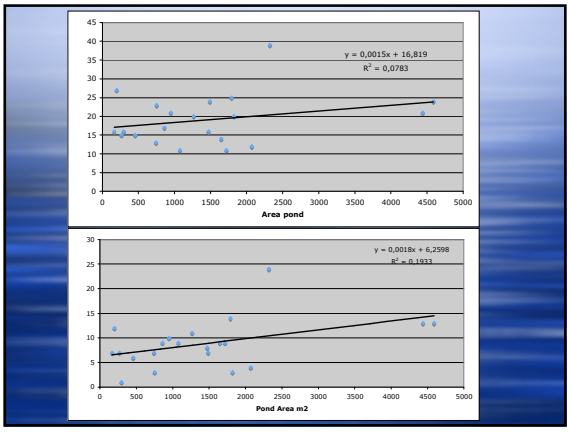
Pearson correlation coefficient (r) and associated prob - abili t y (Ho: r = 0)

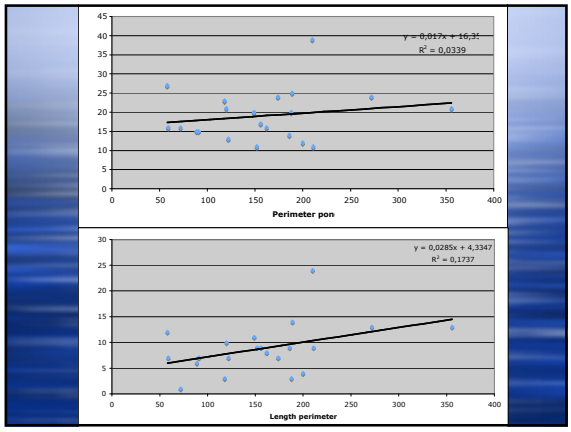
	Total Nb Indivdual		Total Nb Species		Shann on Index		J-eve n-ness Index		Colleop-tera Nb Ind.		Colleop-tera Nb Sp.		Gastero-pod Nb Ind.		Gastero-pod Nb Sp.		Tot -Nb Plant Sp.	
	r	p	r	p	r	p	r	p	r	p	r	p	r	p	r	p	r	p
Sedi ment																		
% Organic	-0.290	0.2 02	0.1 03	0.6 57	0.2 80	0.2 20	0.3 01	0.1 86	-0.230	0.3 15	-0.056	0.8 11	-0.249	0.2 77	0.1 85	0.4 23	0.2 07	0.3 67
Al	**0.457**	**0.037**	0.1 49	0.5 20	-0.225	0.3 28	-0.264	0.2 47	0.2 81	0.2 17	0.2 00	0.3 86	**0.495**	**0.023**	0.1 18	0.6 11	0.1 51	0.5 14
As																		
Ca	-0.266	0.2 44	0.3 48	0.1 22	**0.501**	**0.02 1**	**0.448**	**0.042**	0.0 01	0.9 96	0.1 50	0.5 17	-0.169	0.4 63	0.2 17	0.3 44	0.2 94	0.1 96
Cd																		
Co	0.0 05	0.9 82	-0.186	0.4 20	-0.262	0.2 52	-0.247	0.2 81	-0.127	0.5 83	-0.107	0.6 43	-0.047	0.8 38	-0.124	0.5 92	-0.182	0.4 30
Cr	0.3 70	0.0 99	0.2 28	0.3 21	-0.083	0.7 22	-0.135	0.5 59	0.3 41	0.1 31	0.1 79	0.4 39	0.3 93	0.0 78	0.1 95	0.3 96	0.2 15	0.3 49
Cu	0.0 42	0.8 57	-0.080	0.7 32	0.0 48	0.8 35	0.0 97	0.6 75	0.0 33	0.8 86	-0.177	0.4 42	-0.038	0.8 69	0.1 32	0.5 67	0.1 46	0.5 28
Fe	0.2 17	0.3 44	-0.144	0.5 34	-0.136	0.5 56	-0.089	0.701	0.0 43	0.8 54	0.1 36	0.5 58	0.2 19	0.3 40	-0.145	0.5 31	-0.090	0.6 97
Hg																		
K	**0.453**	**0.039**	0.1 36	0.5 56	-0.243	0.2 89	-0.288	0.2 06	0.3 67	0.1 02	0.2 54	0.2 66	**0.507**	**0.019**	0.0 28	0.9 03	0.0 60	0.7 97
Mg	**0.489**	**0.024**	-0.124	0.5 93	-0.398	0.0 74	-0.4 06	0.0 68	0.1 87	0.4 16	-0.122	0.5 99	**0.428**	**0.053**	-0.046	0.8 41	-0.112	0.6 30
Mn	-0.083	0.7 22	-0.176	0.4 47	-0.023	0.9 22	0.0 26	0.9 11	-0.168	0.4 67	-0.213	0.3 55	-0.068	0.7 68	-0.111	0.6 31	-0.134	0.5 63
Na	-0.119	0.6 07	-0.067	0.7 73	-0.187	0.4 17	-0.192	0.4 04	-0.048	0.8 37	0.2 04	0.3 74	-0.171	0.4 58	-0.336	0.1 37	-0.279	0.2 20
Ni	0.2 85	0.2 10	0.0 90	0.6 99	-0.015	0.9 50	-0.026	0.9 10	0.3 37	0.1 35	0.0 55	0.8 13	0.3 34	0.1 39	0.0 63	0.7 85	0.1 81	0.4 32
P	-0.213	0.3 54	-0.210	0.3 61	0.0 38	0.8 71	0.1 20	0.6 04	-0.115	0.6 19	-0.202	0.3 79	-0.226	0.3 24	0.0 70	0.7 62	0.1 07	0.6 45
Pb	-0.028	0.9 03	-0.173	0.4 52	-0.150	0.5 16	-0.127	0.5 84	-0.238	0.2 99	-0.335	0.1 38	-0.139	0.5 46	0.0 24	0.9 17	-0.132	0.5 68
S	-0.255	0.2 65	0.1 86	0.4 20	**0.439**	**0.047**	**0.439**	**0.046**	-0.052	0.8 22	0.0 14	0.9 52	-0.194	0.4 00	0.1 87	0.4 16	0.1 98	0.3 89
Si	-0.170	0.4 62	0.1 72	0.4 56	0.1 00	0.6 66	0.0 42	0.8 57	0.0 54	0.8 17	0.1 51	0.5 12	-0.087	0.7 07	0.0 38	0.8 70	0.3 13	0.1 67
V	0.2 25	0.3 26	-0.246	0.2 83	-0.363	0.1 06	-0.330	0.1 44	-0.044	0.8 50	-0.026	0.9 12	0.1 56	0.5 01	-0.202	0.3 80	-0.26 8	0.2 41
Zn	-0.049	0.8 33	-0.239	0.2 96	-0.158	0.4 95	-0.117	0.6 14	-0.198	0.3 89	-0.335	0.1 37	-0.156	0.5 01	-0.015	0.9 47	-0.144	0.5 33

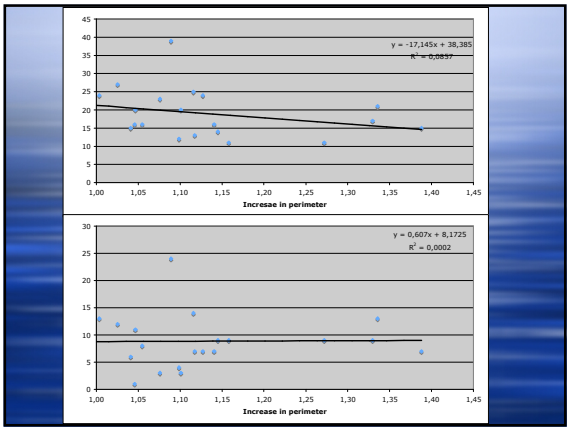
Pearson correlation coefficient (r) and associated probability (H $_o$: r = 0)

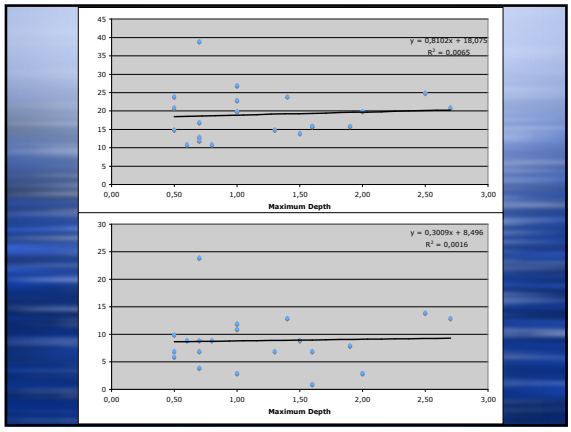
	Total Nb Individuals		Total Nb Species		SHANNON Index		J-evenness Index		Colleoptera Nb Ind.		Colleoptera Nb Sp.		Gasteropod Nb Ind.		Gasteropod Nb Sp.		Tot-Nb Plant Sp.	
	r	p	r	p	r	p	r	p	r	p	r	p	r	p	r	p	r	p
Pond																		
Age	**0,577**	**0,008**	0,264	0,261	-0,138	0,561	-0,188	0,428	**0,555**	**0,011**	0,375	0,104	**0,651**	**0,002**	0,303	0,194	0,273	0,244
Area	-0,263	0,263	0,208	0,379	0,287	0,220	0,243	0,303	-0,279	0,234	-0,039	0,870	-0,211	0,373	0,170	0,475	0,374	0,104
Slope (riparian perimeter)	-0,037	0,877	-0,270	0,250	-0,122	0,609	-0,072	0,764	-0,248	0,293	-0,397	0,083	-0,114	0,631	-0,122	0,610	-0,229	0,331
Vegetation																		
Total Nb Plant Species	0,136	0,567	**0,759**	**0,000**	0,414	0,069	0,275	0,240	0,077	0,747	0,158	0,505	0,182	0,443	**0,881**	**0,000**		
Riparian Plant Cover (%)	0,069	0,771	0,209	0,376	0,011	0,962	-0,044	0,855	-0,062	0,795	0,007	0,977	0,100	0,676	0,160	0,499	0,201	0,396
Floating Plant Cover (%)	**0,600**	**0,005**	**0,437**	**0,054**	0,007	0,976	-0,092	0,701	0,325	0,162	0,103	0,666	**0,654**	**0,002**	0,356	0,124	**0,445**	**0,049**
Submerged Plant Cover (%)	0,105	0,659	0,422	0,064	0,357	0,122	0,275	0,240	0,077	0,747	0,275	0,241	0,163	0,493	0,173	0,465	0,177	0,455
Algal Mat Cover (%)	0,066	0,782	-0,369	0,109	**-0,543**	**0,013**	**-0,545**	**0,013**	-0,224	0,342	-0,368	0,111	-0,003	0,984	-0,193	0,414	-0,212	0,370
Water																		
PH	-0,071	0,766	-0,046	0,849	0,191	0,419	0,231	0,327	0,056	0,816	-0,120	0,614	0,000	0,999	0,128	0,591	0,154	0,516
Alcalinity	0,114	0,634	0,245	0,299	0,234	0,320	0,216	0,360	0,258	0,272	0,101	0,672	0,219	0,352	0,260	0,267	**0,493**	**0,027**
Conductivity	-0,013	0,957	0,267	0,256	0,186	0,433	0,141	0,554	0,162	0,495	0,128	0,590	0,092	0,698	0,192	0,417	0,413	0,070
JTU	0,386	0,093	-0,221	0,349	-0,180	0,447	-0,126	0,598	0,229	0,331	-0,262	0,264	0,370	0,108	-0,033	0,891	0,017	0,942
Color	0,062	0,796	-0,196	0,408	-0,427	0,061	**-0,445**	**0,049**	-0,190	0,422	-0,231	0,327	-0,106	0,655	-0,274	0,243	-0,383	0,096
tot-N	**0,446**	**0,049**	0,150	0,527	-0,081	0,735	-0,098	0,681	**0,590**	**0,006**	0,353	0,127	**0,464**	**0,039**	0,286	0,221	0,146	0,539
NO_3+NO_2	**0,444**	**0,050**	0,121	0,612	-0,070	0,769	-0,079	0,742	**0,561**	**0,010**	0,349	0,131	**0,468**	**0,037**	0,261	0,266	0,118	0,620
NO_2-N	-0,162	0,494	-0,056	0,815	0,112	0,638	0,153	0,519	0,017	0,943	0,061	0,797	-0,138	0,563	0,142	0,549	0,167	0,482
NH_4-N	-0,134	0,572	-0,326	0,160	-0,199	0,401	-0,129	0,589	0,028	0,907	-0,177	0,455	-0,075	0,752	-0,132	0,579	-0,016	0,947
PO_4-P	-0,079	0,741	-0,223	0,345	-0,004	0,986	0,087	0,715	0,076	0,752	-0,218	0,356	-0,096	0,688	-0,015	0,950	0,011	0,965
Tot-P	-0,072	0,762	-0,225	0,341	-0,018	0,939	0,071	0,765	0,101	0,673	-0,217	0,359	-0,094	0,693	-0,021	0,931	0,012	0,959

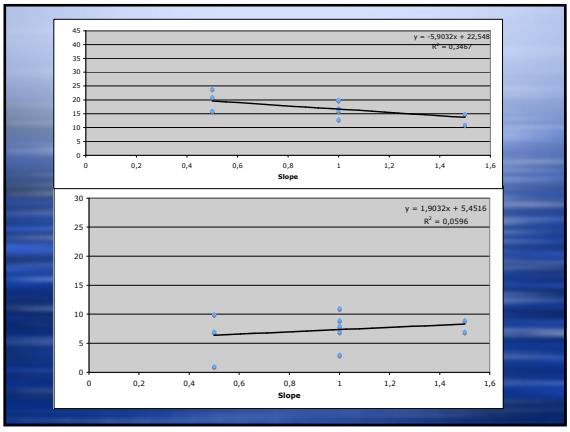






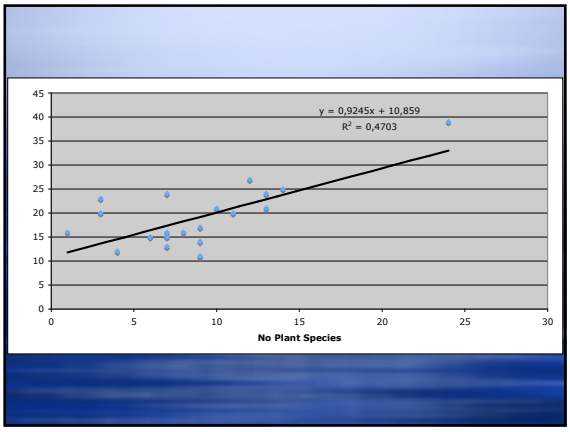






Conclusions

- Geometry alone could not explain biodiversity
- Biodiversity show a positive trend with age and size of pond
- Biodiversity is not affected by ratio perimeter/area and depth of pond



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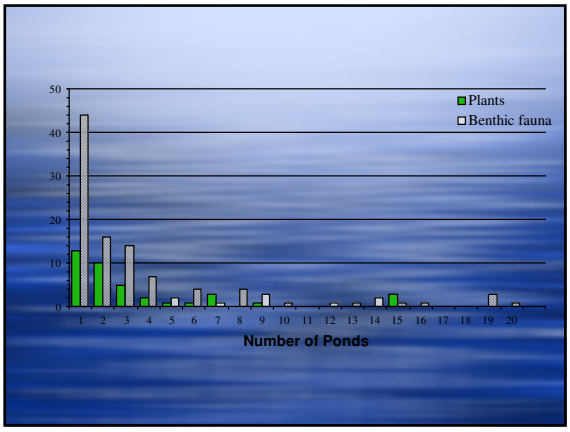

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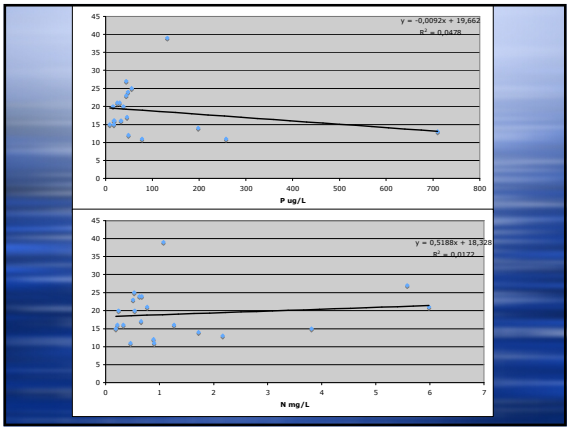

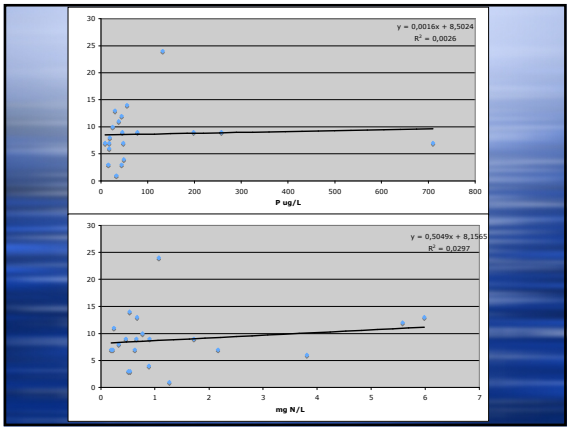

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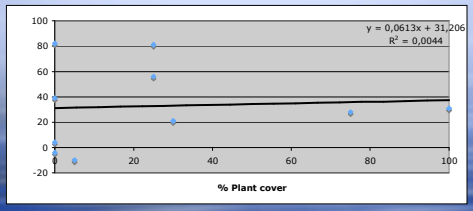
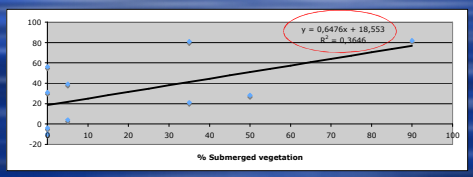
- Most ponds have species unique for that pond - part of biodiversity
- Nutrient level did not affect number of plant and animal species





Conclusions

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- Biodiversity show a positive trend with age and size of pond
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Table 3: Load and retention of nitrogen.

Wetlands	Load	Retention		
	Mean	Mean	Range	%
	kg N / ha / yr	*kg N / ha / yr*		
L. Böslid	35,600	912	730—1,058	2.6
Möllegården	108,200	6,789	657—6,971	6.3
Stjärnarp	7,665	730	547—730	9.5
Tjärby 1	10,250	292	110—730	2.9
Tjärby 2	123,500	- 1,387	- 1,898—438	-1.1
Vallås 1	2,260	146	110—292	6.4
Vallås 2	25,100	584		2.3
Slättåkra	38,580	8,066	6,898—8,650	20.8
Toftanäs	33,160	7,169	714—7,857	21.6
Råbytorp	12,460	583	300—1,000	4.4
Skabersjö	30,000	1,065	662—1,665	6.9
Fastmårup	332,300	-1,513	- 6,900—8,038	-0.4
Ormastorp S.	48,190	4	- 1,274—1,186	0
Magle Wetland	4,050	1,400	1,250 —1,550	34.6
Vomb (E+W)	480 - 700	44	0 —88	0 —7
Isgrannatorp	270	45	45	15

Table 6: Load and retention of phosphorus.

Wetlands	Load	Retention		
	Mean	Mean	Range	%
	kg P / ha / yr	*kg P / ha / yr*		
L. Böslid	833	450		54
Möllegården	2,750	110		4
Tjärby 1	46	18		39
Tjärby 2	666	180		27
Vallås 1	174	-200		-115
Vallås 2	550	11		2
Slättåkra	5,555	500		9
Toftanäs	1,630	131	-95 to 357	16
Råbytorp	166	15	-3.5 to 38	9
Skabersjö	590	60	23 to 97	10
Fastmårup	3,123	320	-12 to 207	10
Ormastorp S.	160	16	-2 to 118	10
Magle Wetland	26.5	6.3	1.7 to 11	24


Photo K. Olsson